dividing the initial period into a number of increments; and
increasing the ratio by an intermediate value at each increment.

Remarks

The indication that Claims 4, 5, and 14-16 would be allowable if rewritten is acknowledged and greatly appreciated. Claims 4, 5, and 14-16 are believed to be allowable as currently written, for the reasons provided below, and are thus maintained herein. Rewritten versions of Claims 4, 5, and 14-16 appear in new Claims 21-25, respectively, which are believed to be allowable.

The specification has been amended merely to address clerical, typographical, spelling, grammatical, and/or punctuation oversights and to remove a reference to a Figure 8. No new matter has been added by virtue of these amendments.

Claim 4 has been amended merely to address a punctuation oversight and to remove unnecessary terminology. Claim 5 has been amended merely to address punctuation oversights. Claim 14 has been amended to correct grammar. Claims 4, 5 and 14, respectively, have not been narrowed by virtue of these amendments and no new matter has been added by virtue of these amendments.

Claims 1-3, 6-13 and 17-20 have been rejected under 35 U.S.C. Section 103(a) as allegedly being unpatentable over U.S. Patent No. 6,426,015 to Xia et al. (hereinafter, simply "Xia") in view of U.S. Patent No. 6,100,202 to Lin et al. (hereinafter, simply "Lin"). These rejections are respectfully traversed.

The Office Action states that Xia teaches preheating a wafer to a preheat temperature (Id. at page 2, item 2 and page 4, item 4). It is respectfully submitted that Xia does not teach such preheating, as the "seasoning" of Xia, as understood, takes place at ambient temperature (see column 2, lines 36-43, and column 4, lines 45-5 1, for example).

The Office Action further states that Xia teaches introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate, wherein a ratio of the dopant precursor gas [*sic*, flow rate to a silicon-containing gas flow rate] has an initial value; increasing the ratio from the initial value during an initial time period, wherein said increasing depends on the wafer

temperature; and maintaining the ratio at the final value during a final period, wherein during the initial period and the final period the dopant precursor gas and the silicon-containing gas react in the plasma [sic] to form the doped silicon dioxide layer on the wafer having about the same dopant concentration during the final period (Id. at page 2, item 2 and page 4, item 4).

It is respectfully submitted that this reading of Xia is incorrect or that the Office Action was incorrectly focussing on the individual gas flows rather than on the ratios of gas flow rates. Xia, as understood, teaches a ratio of dopant precursor gas flow rate to silicon-containing gas flow rate that *decreases* from an initial value to a final value. This decrease is indicated, for example, at column 4, lines 45-56, where the ratio of TEB/TEOS flow rates *decreases* from 112/250 to 160/600 and the ratio of TEPO/TEOS flow rates decreases from 50/250 to 70/600. It is also respectfully submitted that the Office Action's depiction of Xia is further incorrect in that Xia, as understood, does not teach any adjusting of the ratio of dopant precursor gas flow rate to silicon-containing gas flow rate according to wafer temperature. Moreover, it is respectfully submitted that the Office Action's depiction of Xia is still further incorrect in that Xia does not teach the use of a plasma, as later conceded in the Office Action (Id. at page 3, item 2). The Office Action's further concessions regarding the failings of Xia are appreciated and confirmed.

Lin fails to remedy the many deficiencies of Xia. By way of example, Lin also teaches a *decrease* in, or *maintenance* of, the ratio of a dopant precursor gas flow rate to a silicon-containing gas flow rate in separate deposition processes, as indicated in column 15, lines 12-26, where triethyl phosphite flow rate to TEOS flow rate *decreases* from 50/500 in a first deposition to 34/500 in a second deposition and triethyl borane flow to TEOS flow rate is *maintained* at 193/500 in a first and a second deposition. Further, there is nothing in Lin (as understood) that teaches or suggests any adjusting of the ratio of dopant precursor gas to silicon-containing gas flow rate according to wafer temperature. Thus, even if Xia and Lin were capable of combination, *arguendo,* that hypothetical combination would have failed at the relevant time to teach or suggest the claimed invention. The Office Action does not show otherwise.

As to the comments in the Office Action concerning Claims 9 and 19, it is respectfully submitted that it would not have been obvious from Xia's "seasoning" at ambient temperature or from anything in Lin (if combinable, *arguendo)* that a preheat temperature of 350°C could be used in a disparate method such as that of the clai med invention, or from Xia and Lin's teachings (if combinable, *arguendo)* that an initial value of a ratio of dopant precursor gas to silicon-containing gas flow rates could be *increased* from 0.49 to 0.77 in a disparate

method such as that of the claimed invention, or that any of same could have been selected merely as a matter of optimization by routine experimentation in this completely different method of the claimed invention.

In view of the foregoing, it is believed that the rejections of Claims 1-3, 6-13, and 17-20 have been overcome and that Claims 4, 5, 14-16 and 21-25 are allowable.

Conclusion

Claims 1-25 define novel and non-obvious subject matter of the present invention. Accordingly, an early notification that the application is in condition for allowance is earnestly solicited.

Respectfully submitted,
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Appendix 1: Copy of Replacement Paragraph in Marked Form

The replacement paragraph for original paragraph 0005 is set forth below in marked form.

Figure 1[]A is a cross-section of a device layer 105 that [exhibit] exhibits an undesirable etch [rofile] profile known as "footing." Footing occurs when the doped silicon dioxide that is in the lower portion 107 of later 105 is etched at a faster rate than the doped silicon dioxide that is in the upper portion 109 of layer 105.

The replacement paragraph for original paragraph 0033 is set forth below in marked form.

In an exemplary embodiment, contact holes etched into a phosphorous-doped silicon dioxide (PSG) layer formed by the method of Figure 5 have a good etch profile with straight sidewalls and without footing[, as illustrated in Figure 8]. In this example, two mass flow controllers control the SiH_4 flowrate, the PH_3 flowrate, and the dopant/silicon ratio. One mass flow controller is connected to a 100% SiH_4 source and the other mass flow controller is connected to a 50% SiH_4/50% PH_3 source. Specific conditions used to form the PSG layer are listed in Table 1[:] below.

Appendix 2: Copy of Amended Claims in Marked Form and New Claims in Clean Form

4. (Amended) The method of Claim 1, further comprising[,] determining a duration of the initial period by measuring a temperature of the wafer during a test deposition of a doped silicon dioxide layer, wherein the duration is the [length of] time required for the temperature to reach an essentially constant value.

5. (Amended) The method of Claim 1, further comprising:

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test depositions performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant,

whereby the initial value of the ratio is determined.

14. (Amended) The method of Claim 11, further comprising:

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test [deposition] <u>depositions</u> performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant, whereby a set of values of the ratio to be used during the deposition are determined.

21. (New) A method for depositing a doped silicon dioxide layer onto a wafer, the method comprising:

introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate into a plasma, wherein a ratio of the dopant precursor gas flow rate to the silicon-containing gas flow rate has an initial value;

increasing the ratio from the initial value to a final value during an initial period;

determining a duration of the initial period by measuring a temperature of the wafer during a test deposition of a doped silicon dioxide layer, wherein the duration is the time required for the temperature to reach an essentially constant value; and

maintaining the ratio at the final value during a final period,

wherein during the initial period and the final period the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer.

22. (New) A method for depositing a doped silicon dioxide layer onto a wafer, the method comprising:

introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate into a plasma, wherein a ratio of the dopant precursor gas flow rate to the silicon-containing gas fiow rate has an initial value;

increasing the ratio from the initial value to a final value during an initial period;

maintaining the ratio at the final value during a final period, wherein during the initial period and the final period the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer; and

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test depositions performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant, whereby the initial value of the ratio is determined.

23. (New) A method for depositing a doped silicon dioxide layer, the method comprising:

introducing a dopant precursor gas and a silicon-containing gas into a plasma at a dopant precursor gas flow rate and a silicon-containing gas flow rate for a deposition period;

adjusting, during the deposition period, a ratio of the dopant precursor gas flow rate and the silicon-containing gas flow rate as a function of wafer temperature, whereby the dopant precursor gas and the silicon-containing gas react in the plasma to form the doped silicon dioxide layer having a defined dopant concentration;

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test deposition performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant,

whereby a set of values of the ratio to be used during the deposition are determined.

24. (New) The method of Claim 23, wherein:

the temperature profile comprises an initial period during which the temperature of the wafer is increasing and a final period during which the temperature of the wafer is constant; and

during the deposition the ratio is increased from an initial value to a final value during the initial period and the ratio is held at the final value during the final period.

25. (New) The method of Claim 24, wherein increasing the ratio from the initial value to the final value comprises:

dividing the initial period into a number of increments; and

increasing the ratio by an intermediate value at each increment.

Appendix 3:Copy of Pending Claims, Including Any Amendment or Addition Herein, in Clean Form

1. A method for depositing a doped silicon dioxide layer onto a wafer comprising:

introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate into a plasma, wherein a ratio of the dopant precursor gas flow rate to the silicon-containing gas flow rate has an initial value;

increasing the ratio from the initial value to a final value during an initial period; and

maintaining the ratio at the final value during a final period,

wherein during the initial period and the final period the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer.

2. The method of Claim 1, wherein a portion of the doped silicon dioxide layer deposited during the initial period has about the same dopant concentration as a portion of the doped silicon dioxide layer deposited during the final period.

3. The method of Claim 1, further comprising etching one or more contact holes through the doped silicon dioxide layer, wherein the one or more contact holes have straight sidewalls.

4. (Amended) The method of Claim 1, further comprising determining a duration of the initial period by measuring a temperature of the wafer during a test deposition of a doped silicon dioxide layer, wherein the duration is the time required for the temperature to reach an essentially constant value.

5. (Amended) The method of Claim 1, further comprising:

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test depositions performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant,

whereby the initial value of the ratio is determined.

6. The method of Claim 1, wherein increasing the ratio from the initial value to the final value comprises:

dividing the initial period into a number of increments; and

increasing the ratio by an intermediate value at each increment.

7. The method of Claim 1, wherein the dopant precursor gas is phosphine and the silicon-containing precursor gas is silane.

8. The method of Claim 1 further comprising preheating the wafer to a preheat temperature.

9. The method of Claim 8, wherein the dopant precursor gas is phosphine and the silicon-containing precursor gas is silane, the preheat temperature is 350°C, the initial value of the ratio is about 0.49, and the final value of the ratio is about 0.77.

10. The method of Claim 1 wherein the dopant precursor gas is selected from the group consisting of PH_3, SiF_4, and B_2H_6.

11. A method for depositing a doped silicon dioxide layer comprising:

introducing a dopant precursor gas and a silicon-containing gas into a plasma at a dopant precursor gas flow rate and a silicon-containing gas flow rate for a deposition period; and

during the deposition period, adjusting a ratio of the dopant precursor gas flow rate and the silicon-containing gas flow rate as a function of wafer temperature, whereby the dopant precursor gas and silicon-containing gas react in the plasma to form the doped silicon dioxide layer having a defined dopant concentration.

12. The method of Claim 11, wherein the dopant concentration is essentially uniform throughout the layer.

13. The method of Claim 11, further comprising etching one or more contact holes through the doped silicon dioxide layer, wherein said one or more contact holes have essentially straight sidewalls.

14. (Amended) The method of Claim 11, further comprising:

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test depositions performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant, whereby a set of values of the ratio to be used during the deposition are determined.

15. The method of Claim 14, wherein:

the temperature profile comprises an initial period during which the temperature of the wafer is increasing and a final period during which the temperature of the wafer is constant; and

during the deposition the ratio is increased from an initial value to a final value during the initial period and the ratio is held at the final value during the final period.

16. The method of Claim 15, wherein increasing the ratio from the initial value to the final value comprises:

dividing the initial period into a number of increments; and

increasing the ratio by an intermediate value at each increment.

17. The method of Claim 11, wherein the dopant precursor gas is phosphine and the silicon-containing precursor gas is silane.

18. The method of Claim 11 further comprising preheating the wafer to a preheat temperature.

19. The method of Claim 18, wherein the dopant precursor gas is phosphine and the silicon-containing precursor gas is silane, the preheat temperature is 350°C, the initial value of the ratio is about 0.49, and the final value of the ratio is about 0.77.

20. The method of Claim 11 wherein the dopant precursor gas is selected from the group consisting of PH_3, SiF_4, and B_2H_6.

21. (New) A method for depositing a doped silicon dioxide layer onto a wafer, the method comprising:

introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate into a plasma, wherein a ratio of the dopant precursor gas flow rate to the silicon-containing gas flow rate has an initial value;

increasing the ratio from the initial value to a final value during an initial period;

determining a duration of the initial period by measuring a temperature of the wafer during a test deposition of a doped silicon dioxide layer, wherein the duration is the time required for the temperature to reach an essentially constant value; and

maintaining the ratio at the final value during a final period,

wherein during the initial period and the final period the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer.

22. (New) A method for depositing a doped silicon dioxide layer onto a wafer, the method comprising:

introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate into a plasma, wherein a ratio of the dopant precursor gas flow rate to the silicon-containing gas fiow rate has an initial value;

increasing the ratio from the initial value to a final value during an initial period;

maintaining the ratio at the final value during a final period, wherein during the initial period and the final period the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer; and

measuring a concentration of dopant incorporated into a portion of a silicon dioxide layer as a function of the ratio for a first series of test depositions performed at a constant temperature;

repeating the measurement of dopant concentration for a second series of test depositions performed at a different constant temperature; and

measuring a temperature profile of the wafer during a third test deposition wherein the temperature is not held constant, whereby the initial value of the ratio is determined.

23. (New) A method for depositing a doped silicon dioxide layer, the method comprising:

introducing a dopant precursor gas and a silicon-containing gas into a plasma at a dopant precursor gas flow rate and a silicon-containing gas flow rate for a deposition period;